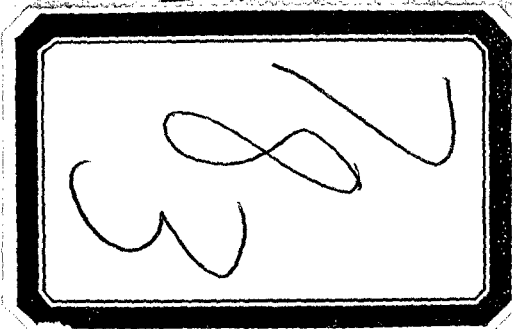


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GROSS PATTERN OF INJURY OF 109 SURVIVORS  
OF FIVE TRANSPORT ACCIDENTS

A. Howard Hasbrook  
Director

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AVIATION CRASH INJURY RESEARCH  
of Cornell University  
2713 East Airline Way  
Sky Harbor Airport  
Phoenix, Arizona

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## TABLE OF CONTENTS

	page
Abstract	i
Foreword	ii
Summary	1
Recommendations	5
Introduction	6
Accident Descriptions	8-17
Accident Severity	18
Forcible Ejection	18
Delethalization and Direction of Seating	18
Rates of Survival	19
Types of Injury and their Frequency	20-41
Summary of Injuries	42
Appendix A - List of Typical Injuries	45
Appendix B - Typical Av-CIR Medical Report	49
Appendix C - Degrees of Injury used by Av-CIR	55

## ABSTRACT

The gross pattern of injury - site, frequency, and seriousness - of 109 survivors of five transport accidents is shown. The accidents include four extremely severe conditions of crash force - and aircraft damage; the fifth involved moderate crash force and moderate aircraft damage. Two of the crashes - one of which involved rearward facing seats - were of similar nature. Lack of de-lethalized design in the seat structures and lack of effective "tie-down" of seats were factors in producing injury in survivable areas in three of the accidents. The two principal types of injuries sustained by the survivors were concussion (59.5%) and fractures of the lower extremities (47.1%).

## FOREWORD

The cooperation of the United States Departments of the Army, Navy, and Air Force, the Civil Aeronautics Board and the Civil Aeronautics Administration, as well as of many flight surgeons and civilian doctors - who were in charge of survivors - is gratefully acknowledged. Without the cooperation and assistance of these and other individuals too numerous to name here, it would have been impossible to compile the data contained in this report.

Funds for this particular study were provided by the Bureau of Medicine and Surgery and the Office of Naval Research of the U. S. Navy, and by the U. S. Air Force.

## SUMMARY

This report discusses the distribution and seriousness of injuries sustained by the survivors of five survivable transport aircraft accidents. One of the five accidents resulted in a relatively low injury rate and only moderate structural damage; the other four accidents showed higher injury rates, more aircraft damage, and greater impact severity. Comparison of the moderate accident with the four severe accidents indicates that statistical accident data can be misleading unless accidents are classified in a meaningful way — by using "degrees" of severity. For purposes of classifying severity, factors should be used which relate to the impact conditions (flight path angle, velocity, aircraft attitude, type of terrain, etc.) as well as to the resulting demolition of the aircraft and its major components.

To obtain a clear picture, in this summary, of the injury pattern developed in severe but survivable accidents, only the highlights of the four severe crashes are reviewed.

The table on page 3 shows that the major injury to be concerned with in relation to rescue and medical assistance is concussion. Almost 50% of the survivors involved in the four accidents sustained concussion which resulted in unconsciousness for periods exceeding five minutes. Strangely, skull fractures among survivors were relatively rare.

The high rate of concussion implies that (a) rescue personnel may expect to find many survivors who will require assistance in evacuating the aircraft, and (b) care must be exercised by rescue personnel not to assume that unconscious persons have been fatally injured.

In view of the fact that a third of the survivors sustained dangerous degrees of concussion, it is indicated that prompt medical treatment for this type of injury will be needed on a wide-scale basis.

Although 23% of the survivors sustained fractures of the thoracic cage, less than 3% suffered intrathoracic injury.

The rate for cervical spine injury was low; however, the combined rate for the dorsal and lumbar portions of the spine amounted to almost 15%. Since this type of injury implies a danger of paralysis of the lower extremities, rescue and evacuation assistance may be required by up to 15% of the survivors.

Pelvic fractures of a non-dangerous degree were sustained by 11.5% of the survivors; while not necessarily rendering these persons completely immobile, their evacuation from the aircraft without assistance may be



less rapid than would be desirable under the circumstances.

The low rate of intra-abdominal injuries, particularly of a dangerous degree, is certainly of interest and indicates that the so-called "serious injury effects of safety belts" have been magnified beyond fact.

Almost 19% of the upper extremities (arms and/or hands) were fractured. Since a few persons sustained fractures of both arms or hands, a slightly lower percentage of the survivors sustained fractures of the upper extremities. However, this rate of upper extremity fracture is of importance in relation to the passengers' inability to open exits and/or extricate themselves from the wreckage.

Dislocation of the upper extremities was relatively rare.

The rate of fracture of the lower extremities (legs and feet) was more than double that of the upper extremities - almost 48%. This indicates that a large number of survivors may require assistance in evacuating the wreckage even though they may not have sustained concussion.

In addition, dislocation of the lower extremities is considered of importance in this respect, since this type of injury involved almost 15% of the lower extremities.

It is shown that (a) concussion with unconsciousness ranging beyond five minutes, and fractures of the lower extremities may be more apt to be sustained in severe but survivable transport accidents than most other injuries - assuming that these four severe accidents are typical.

Due to the immobilizing effect of these two types of injury, it is apparent that speedy rescue assistance will be required in severe but survivable transport crashes if the aircraft and its occupants are threatened by a post-crash fire.

Insufficient tie-down strength and lack of de-lethalized design of the seats were related to injury; there was no apparent relation between injury and direction of seating.

In order to reduce the rates of concussion and lower extremity fracture, improved design of the seats and their tie-down (anchorage) should be utilized.

Increased tie-down strength will reduce excessive exposure of the human body to injury if, concurrently with such increases in tie-down strength, effective de-lethalization is incorporated in all portions of the seats and adjacent structure, regardless of direction of seating.

PERCENT OF 87 SURVIVORS SUSTAINING INJURY  
BY SITE AND DEGREE OF INJURY\*

Site and Type of Injury	Dangerous	Non- Dangerous	Minor	Total
<b>HEAD</b>				
Concussion	33.3%	16.1%	10.3%	59.7%
Skull Fractures	5.7	0.0	0.0	5.7
Facial Fractures	0.0	17.2	0.0	17.2
Surface Injuries	0.0	18.4	51.7	70.1
<b>UPPER TORSO</b>				
Thoracic Cage Fractures	0.0%	23.0%	0.0%	23.0%
Intrathoracic Injuries	2.3	0.0	0.0	2.3
Surface Injuries	0.0	5.7	10.3	16.0
<b>SPINAL INJURIES</b>				
Cervical	2.3%	2.3%	0.0%	4.6%
Dorsal	6.9	1.1	0.0	8.0
Lumbar	2.3	3.4	1.1	6.8
<b>LOWER TORSO</b>				
Pelvic Fractures	0.0%	11.5%	0.0%	11.5%
Intra-abdominal Injuries	3.4	1.1	0.0	4.5
Surface Injuries	0.0	1.1	12.6	13.7
<b>UPPER EXTREMITIES</b>				
Fractures	1.1%	17.2%	0.0%	18.3%
Dislocations	0.0	2.3	0.0	2.3
Surface Injuries	0.0	2.3	28.7	31.0
<b>LOWER EXTREMITIES</b>				
Fractures	3.4%	42.5%	1.1%	47.0%
Dislocations	0.0	14.9	0.0	14.9
Surface Injuries	0.0	11.5	46.0	57.5

TABLE 1.

\* Does not include survivors of moderate (Buffalo) accident.



## RECOMMENDATIONS

It is recommended that:

1. All aviation medical and rescue personnel be alerted to the frequency of concussion and lower extremity fractures that may be expected among survivors of severe but survivable transport accidents.
2. All non-medical rescue personnel be trained in the proper handling of survivors sustaining the types of injuries which may normally be expected in such accidents.
3. Seat tie-down (anchorage) strength be increased to prevent complete failure of the seats prior to demolition of the basic fuselage structure.
4. All seats and components adjacent to the occupants be adequately de-lethalized.
5. All possible means of preventing post-crash fires be utilized in order to provide sufficient time to evacuate all occupants.

## INTRODUCTION

Current transport seating capacity varies from 40 to 100 passengers per aircraft; future transports - particularly of the jet type - are expected to carry as many as 230 passengers per aircraft. Survivable accidents involving these, as well as present-day aircraft, will therefore involve large numbers of people - many of whom may require assistance during emergency evacuation from the aircraft. In addition, many may need prompt medical aid.

Knowledge of the gross areas and severity of injury which may be expected in such emergencies should therefore be of value if adequate rescue and medical assistance is to be provided at the scene of a survivable crash. Therefore, information on the gross sites and seriousness of injuries sustained by 109 survivors of five survivable transport accidents is presented.

Possible causes of the injuries and the reasons for variations in frequency of types of injuries in the five accidents are also reviewed. However, no statistical conclusions are drawn.

The five accidents involved two Convair 240's, one Curtiss C-46, one Douglas DC-6, and one Douglas DC-6A (C-118). Four of the accidents involved severe impact conditions and resulted in extremely severe damage to the aircraft; the remaining accident (one of the two Convair 240's) involved moderate impact conditions and resulted in moderate damage to the aircraft fuselage.

Data on those fatally injured in the accidents are not presented in this report; such data will be contained in a future report.

One of the five aircraft, the DC-6A (C-118), was equipped with rearward-facing seats.

In three of the accidents, all but two sets of occupied seats tore free - including all of the rearward-facing seats in the C-118.

Lack of sufficient seat tie-down strength in four of the accidents, and lack of de-lethalized seat design in two appear to have been the principal causes of dangerous injury to persons who originally occupied survivable (reasonably intact) areas of the aircraft.

Direction of seating does not appear to have been a primary factor in the over-all production of injuries, although some variations in rate of injury to specific body areas appear to be loosely associated with seating direction.

The categories of injury classification used in this report are:

- (a) dangerous
- (b) non-dangerous
- (c) minor

Definitions of these classifications may be found in Appendix C.

In many cases, a survivor will have sustained injuries of varying degrees and in various body areas; a person - using a hypothetical example - might have sustained concussion to a dangerous degree, a non-dangerous fracture of the thoracic cage, a non-dangerous injury to the upper torso, and a non-dangerous injury of an extremity. All of these injuries would be counted and listed in the appropriate tables. A more detailed description of such cases of multiple injuries will be presented in a future report.

## ACCIDENT DESCRIPTION

### CONVAIR 240 ACCIDENT AT BUFFALO, NEW YORK (AMERICAN AIRLINES, 1/20/54)

The Convair 240 accident at Buffalo, New York, involved a high-speed intentional forced landing down-wind with the landing gear retracted, on frozen, snow-covered ground. One wing was torn off during ground impact with trees during the deceleration slide. The entire fuselage remained substantially intact (Figure 1) although the left side of the cockpit was partially sheared away by impact with trees. One passenger's safety-belt anchorage failed, allowing him to become a missile.

This accident was of moderate severity and resulted in moderate damage to the aircraft; the following four accidents involved severe impact conditions and severe damage to the aircraft.

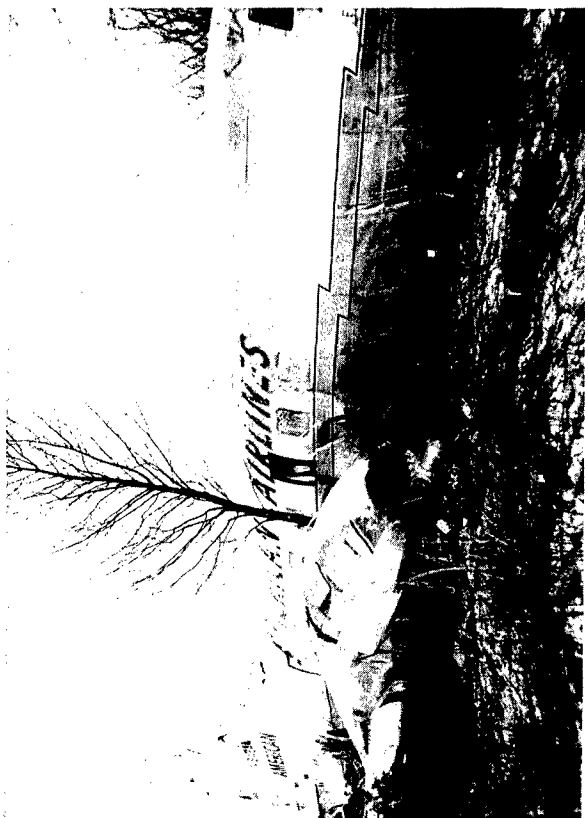


Figure 1. CV-240 accident at Buffalo, N. Y.



## ACCIDENT DESCRIPTION

### CONVAIR 240 ACCIDENT AT SPRINGFIELD, MISSOURI (AMERICAN AIRLINES, 3/21/55)

The Convair 240 accident at Springfield, Missouri, occurred at night when the aircraft was inadvertently flown into the ground at a speed in excess of 140 mph while the aircraft was in a shallow descending turn; the gear was retracted. The right wing disintegrated at impact and the left wing tore off during the subsequent deceleration. The entire fuselage was severely damaged but remained reasonably intact above the floor, with the exception of complete separation between the cockpit and the passenger cabin (Figure 2). However, the floor structure in the passenger cabin was severely damaged throughout and all but the two rearmost sets of seats tore completely free.

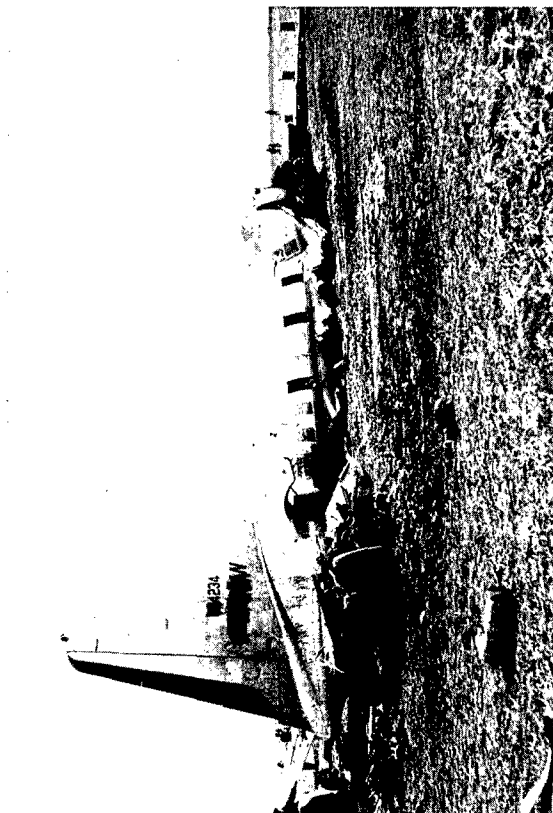
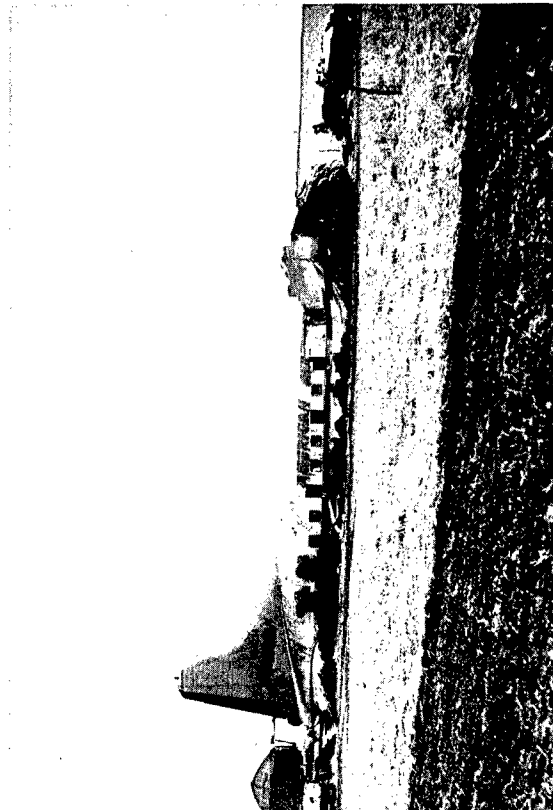
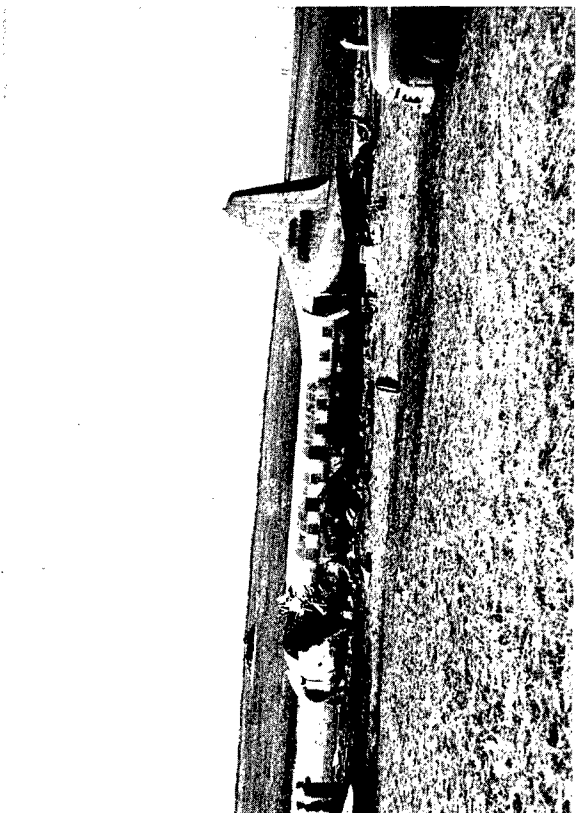
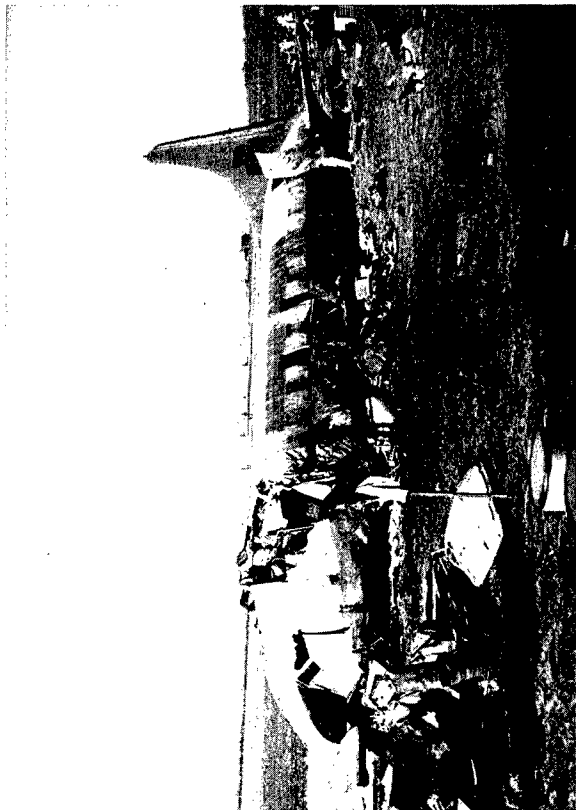


Figure 2. CV-240 accident at Springfield, Mo.

## ACCIDENT DESCRIPTION

DOUGLAS DC-6 ACCIDENT AT ELIZABETH, NEW JERSEY  
(NATIONAL AIRLINES, 2/11/52)

The DC-6 accident at Elizabeth, New Jersey, involved an approach-speed impact with the nose and right wing down slightly; this aircraft also broke into three sections. The forward cabin and cockpit were completely disintegrated. The walls and ceiling over the center section were also disintegrated. The rear cabin section subsequently struck sideways against a 2-foot diameter tree and was broken in two aft of the galley section (Figure 3). However, some of the seats remained attached to the floor.



Figure 3. DC-6 accident at Elizabeth, N. J.

ACCIDENT DESCRIPTION  
  
CURTISS C-46 ACCIDENT AT LOUISVILLE, KENTUCKY  
(RESORT AIRLINES, 9/28/53)

The C-46 accident at Louisville, Kentucky, involved a nose-down angle of approximately 40° at an impact speed in excess of 140 mph; all structure ahead of the front spar - including a portion of the passenger cabin - was completely disintegrated. The remainder of the passenger cabin remained reasonably intact (Figure 4) as did major portions of the floor in this section. However, all of the occupied seats tore free.

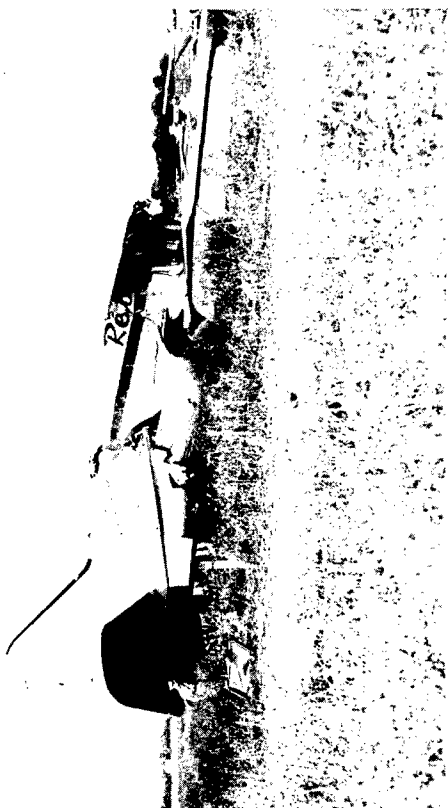
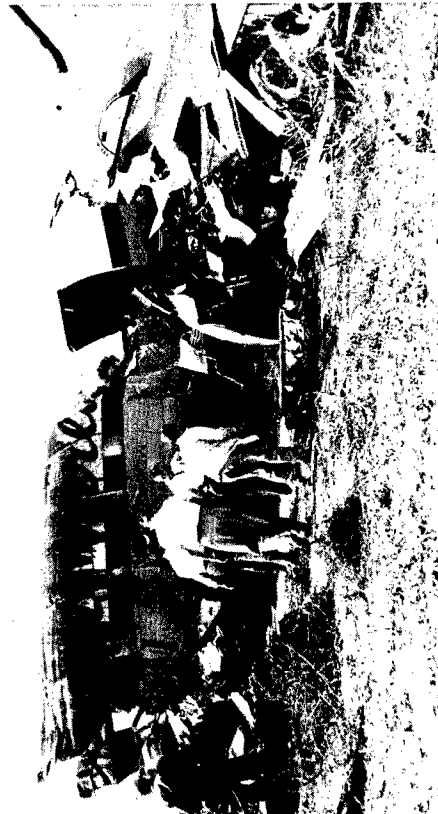


Figure 4. C-46 accident at Louisville, Ky.

## ACCIDENT DESCRIPTION

### DOUGLAS DC-6A ACCIDENT AT MCGUIRE AIR FORCE BASE, NEW JERSEY (MATS, 7/13/56)

The military DC-6A (C-118) accident at McGuire Air Force Base in New Jersey involved an approach-speed impact in a flat, wooded area during a take-off into a thunderstorm and squall-line activity. The aircraft was essentially level at impact but it struck three large earthen mounds which disintegrated the belly structure underneath the floor. The aircraft broke into three sections. The forward cabin and cockpit structures disintegrated, with the exception of the floor structure. The center section, walls, and ceiling were also completely disintegrated, but the floor remained reasonably intact. The rear cabin section remained almost completely intact with the exception of the belly structure underneath the floor (Figure 5). All of the passenger seats faced rearward except two sets just aft of the cockpit. All of the seats -- as well as two litters -- tore free from the aircraft.

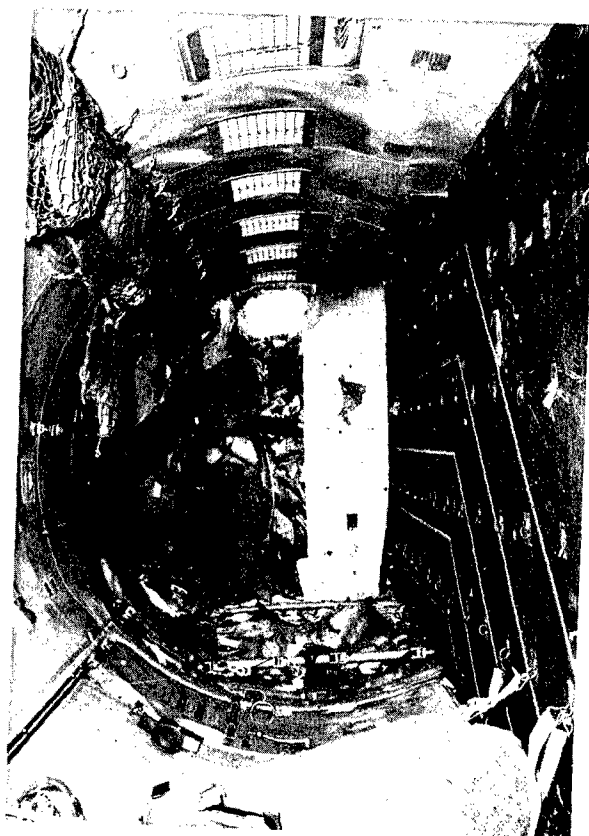
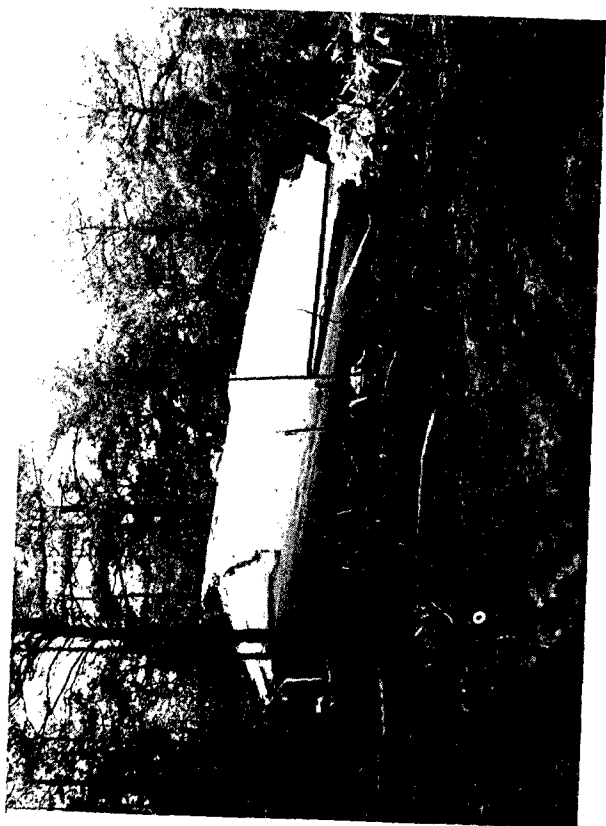


Figure 5. DC-6A (C-118) accident at McGuire AFB, N. J.



## ACCIDENT SEVERITY

The two accidents involving the DC-6 and the DC-6A (C-118) were very similar in many details insofar as the impact and general damage conditions were concerned. The Convair 240 accident at Springfield involved greater magnitudes of crash force in the vertical direction than did the other four accidents. The C-46 crash was the most violent in relation to the magnitude of crash force; in addition, it was the "cleanest" accident relative to the direction and the minimum number of force impulses; the principal crash force apparently was in excess of 25g in the longitudinal direction.

## FORCIBLE EJECTION

In three of the accidents - Springfield (CV-240), McGuire (C-118), and Louisville (C-46) - a majority of the occupants were forcibly ejected from the aircraft during the impacts and subsequent deceleration. In the Elizabeth accident, the persons occupying the forward and center section areas were likewise ejected and forcibly involved with disintegrating structure. No occupants were ejected from the aircraft in the Buffalo accident.

## DELETHALIZATION AND DIRECTION OF SEATING

The seats in the two Convairs and most of the seats in the DC-6 were forward-facing and of a delethalized design. In the C-46 all of the seats were forward-facing but were not of a delethalized design - approximately 50% of the fatal injuries sustained in this C-46 crash were related to specific design features of the seat-backs. In the DC-6A (C-118), with the exception of two sets of seats, all of the seats were rearward-facing and not of a delethalized design.

## RATES OF SURVIVAL

Although no attempt has been made to draw statistical conclusions concerning the relative survival rates in the five accidents, it is of interest that the lowest rate of survival involved rearward-facing seats (in the C-118) which were not of a delethalized design; the next lower rate of survival involved the C-46 which had non-delethalized forward-facing seats. In both of these accidents all of the occupied seats tore free. In the Springfield and Elizabeth accidents the seats were forward facing\* and were of a delethalized design; the higher survival rate in the Springfield accident could be attributed to the fact that the passenger cabin did not disintegrate, while the forward and center section areas in the Elizabeth accident did disintegrate.

Disintegration and impact conditions in the McGuire DC-6A (C-118) and Elizabeth DC-6 accidents were very similar and it is therefore difficult to find a definite reason for the difference in survival rate unless it can be attributed to the differences in delethalization, direction of seating, and the ratio of seat tie-down failure.

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\* With the exception of two sets of sideward seats and two sets of rearward seats in the Elizabeth accident.

NUMBER AND PERCENTAGE OF SURVIVORS  
IN FIVE TRANSPORT ACCIDENTS

AIRCRAFT MODEL AND ACCIDENT LOCATION	NUMBER AND PERCENTAGE OF SURVIVORS	
	No.	%
CV-240, Buffalo, N. Y.	22	100.0
CV-240, Springfield, Mo.	22	66.7
DC-6, Elizabeth, N. J.	33	55.0
C-46, Louisville, Ky.	16	41.0
DC-6A (C-118), McGuire AFB, N. J.	21	37.5

TABLE 2.

## TYPES OF INJURY AND THEIR FREQUENCY

### CONCUSSION

The rate of dangerous concussion was highest in the C-46 (Louisville) accident. It was almost three times that of the Elizabeth DC-6 accident and approximately twice the rate of the McGuire C-118 and Springfield CV-240 accidents.

Since all of the fatalities in the C-46 reportedly involved head injuries - many of which were attributed to a specific design of the back-rests of the seats - it is considered that the high rate of dangerous concussion among the survivors of the C-46 was also related to the non-delethalized design of the seat backs.

It is of interest that although the dangerous concussion rate was highest in the C-46 accident, its rate of non-dangerous concussion was the lowest of the four severe accidents. This implies that when head impact did occur in the C-46 accident, dangerous - rather than non-dangerous - concussion was more apt to be sustained due to the non-delethalized design of the seats in this aircraft.

The rates of non-dangerous concussion in the Springfield, Elizabeth, and McGuire accidents are reasonably alike and merely indicate that a substantial number of persons involved in severe but survivable transport crashes can be expected to sustain concussion to a serious but non-dangerous degree.

These rates of both dangerous and non-dangerous concussion are significant in relation to emergency evacuation and subsequent medical treatment, since a dangerous degree of concussion (by Av-CIR standards) involves unconsciousness ranging from approximately thirty minutes to two hours. Non-dangerous concussion involves unconsciousness ranging from five minutes up to thirty minutes. Thus, unconsciousness for extended periods among a rather large percentage of survivors may be expected in crashes of transport aircraft involving severe and/or extremely severe impact and demolition conditions.

NUMBER OF SURVIVORS AND DEGREE OF  
CONCUSSION

AIRCRAFT MODEL AND ACCIDENT LOCATION	NUMBER AND PERCENTAGE OF SURVIVORS		SURVIVORS WITH CONCUSSION TO:					
			DANGEROUS DEGREE		NON-DANGEROUS DEGREE		MINOR DEGREE	
	No.	%	No.	%	No.	%	No.	%
CV-240 Buffalo, N. Y.	22	100.0	1	4.5	0	0.0	0	0.0
CV-240 Springfield, Mo. *	22	66.7	5	29.4	4	23.5	3	17.6
DC-6 Elizabeth, N. J.	33	55.0	7	21.2	5	15.2	4	12.1
C-46 Louisville, Ky.	16	41.0	10	62.5	1	6.3	0	0.0
DC-6A (C-118) McGuire AFB, N. J. (Rearward-facing seats)	21	37.5	7	33.3	4	19.0	2	9.5

\* Five (5) survivors without authoritative medical details not included in the injury columns. Percentage taken from seventeen (17) survivors.

TABLE 3.

## SKULL FRACTURE

The DC-6 (Elizabeth) accident involved the highest rate of dangerous skull fracture, the C-46 was the next highest, and the DC-6A (C-118) the lowest (with the exception of the other two accidents in which none was reportedly sustained). There is some evidence to indicate that the high rate of dangerous skull fractures in the Elizabeth accident may have been related to forcible impact of the hat-rack structure against the heads of the occupants as the ceiling flexed downward; numerous V-shaped dents in the tops of the seat-backs "mated" with the rigid edge of the hat-rack.

In the C-46, impingement of the heads of the occupants against rigid steel tubes in the seat-backs was related to the incidence of dangerous skull fractures in this particular accident.

It is of interest that there were no reported cases of non-dangerous skull fracture in any of the accidents. In other words, when skull fracture was sustained, it was either of a severe degree, which in itself placed the injury in a "dangerous" category or it was of a lesser degree but accompanied by concussion — which automatically places such an injury in the dangerous category.

NUMBER OF SURVIVORS AND DEGREE OF  
SKULL FRACTURES

AIRCRAFT MODEL AND ACCIDENT LOCATION	NUMBER AND PERCENTAGE OF SURVIVORS		SURVIVORS WITH SKULL FRACTURES TO:					
			DANGEROUS DEGREE		NON-DANGEROUS DEGREE		MINOR DEGREE	
	No.	%	No.	%	No.	%	No.	%
CV-240 Buffalo, N. Y.	22	100.0	0	0.0	0	0.0	0	0.0
CV-240 Springfield, Mo. *	22	66.7	0	0.0	0	0.0	0	0.0
DC-6 Elizabeth, N. J.	33	55.0	3	9.1	0	0.0	0	0.0
C-46 Louisville, Ky.	16	41.0	1	6.3	0	0.0	0	0.0
DC-6A (C-118) McGuire AFB, N. J. (Rearward-facing seats)	21	37.5	1	4.8	0	0.0	0	0.0

\* Five (5) survivors without authoritative medical details not included in the injury columns. Percentage taken from seventeen (17) survivors.

TABLE 4.

## FACIAL FRACTURES

The highest rate of facial fractures was sustained in the DC-6A (C-118) accident which involved non-delethalized, rearward-facing seats that tore free. Several survivors of this accident reported that they distinctly remembered seeing the next adjacent seat-backs "rushing" toward them and striking their faces.

NUMBER OF SURVIVORS AND DEGREE OF  
FACIAL FRACTURES

AIRCRAFT MODEL AND ACCIDENT LOCATION	NUMBER AND PERCENTAGE OF SURVIVORS		SURVIVORS WITH FACIAL FRACTURES TO:					
			DANGEROUS DEGREE		NON-DANGEROUS DEGREE		MINOR DEGREE	
	No.	%	No.	%	No.	%	No.	%
CV-240 Buffalo, N. Y.	22	100.0	0	0.0	0	0.0	0	0.0
CV-240 Springfield, Mo. *	22	66.7	0	0.0	3	17.6	0	0.0
DC-6 Elizabeth, N. J.	33	55.0	0	0.0	3	9.1	0	0.0
C-46 Louisville, Ky.	16	41.0	0	0.0	3	18.8	0	0.0
DC-6A (C-118) McGuire AFB, N. J. (Rearward-facing seats)	21	37.5	0	0.0	6	28.6	0	0.0

\* Five (5) survivors without authoritative medical details not included in the injury columns. Percentage taken from seventeen (17) survivors.

TABLE 5.

## SURFACE INJURIES TO THE HEAD

The rate of non-dangerous surface injuries to the head is fairly uniform except for the Buffalo accident and the McGuire crash - the latter involving rearward-facing seats.

NUMBER OF SURVIVORS AND DEGREE OF  
SURFACE INJURIES TO THE HEAD

AIRCRAFT MODEL AND ACCIDENT LOCATION	NUMBER AND PERCENTAGE OF SURVIVORS		SURVIVORS WITH SURFACE INJURIES TO THE HEAD TO:					
			DANGEROUS DEGREE		NON-DANGEROUS DEGREE		MINOR DEGREE	
	No.	%	No.	%	No.	%	No.	%
CV-240 Buffalo, N. Y.	22	100.0	0	0.0	1	4.5	3	13.6
CV-240 Springfield, Mo. *	22	66.7	0	0.0	3	17.6	11	64.7
DC-6 Elizabeth, N. J. **	33	55.0	0	0.0	4	12.1	12	36.4
C-46 Louisville, Ky.	16	41.0	0	0.0	2	12.5	9	56.3
DC-6A (C-118) McGuire AFB, N. J. (Rearward-facing seats)	21	37.5	0	0.0	7	33.3	13	61.9

\* Five (5) survivors without authoritative medical details not included in the injury columns. Percentage taken from seventeen (17) survivors.

\*\* 45.5% of the survivors had multiple body bruises.

TABLE 6.



## CERVICAL SPINE INJURIES

Despite the severity of four of the crashes, the rate of cervical spine injury was relatively low; only one person in each of the four severe accidents sustained this type of injury.

NUMBER OF SURVIVORS AND DEGREE OF  
CERVICAL SPINE INJURIES

AIRCRAFT MODEL AND ACCIDENT LOCATION	NUMBER AND PERCENTAGE OF SURVIVORS		SURVIVORS WITH CERVICAL SPINE INJURIES TO:					
			DANGEROUS DEGREE		NON-DANGEROUS DEGREE		MINOR DEGREE	
	No.	%	No.	%	No.	%	No.	%
CV-240 Buffalo, N. Y.	22	100.0	0	0.0	0	0.0	0	0.0
CV-240 Springfield, Mo. *	22	66.7	1	5.9	0	0.0	0	0.0
DC-6 Elizabeth, N. J.	33	55.0	0	0.0	1	3.0	0	0.0
C-46 Louisville, Ky.	16	41.0	0	0.0	1	6.3	0	0.0
DC-6A (C-118) McGuire AFB, N. J. (Rearward-facing seats)	21	37.5	1	4.8	0	0.0	0	0.0

\* Five (5) survivors without authoritative medical details not included in the injury columns. Percentage taken from seventeen (17) survivors.

TABLE 7.

## DORSAL SPINE INJURIES

A high rate of dangerous injuries to the dorsal spine was sustained in the Springfield accident; this rate was attributed to the high magnitude of vertical force imposed in the crash, as compared to the lesser vertical force in the other four accidents.

NUMBER OF SURVIVORS AND DEGREE OF  
DORSAL SPINE INJURIES

AIRCRAFT MODEL AND ACCIDENT LOCATION	NUMBER AND PERCENTAGE OF SURVIVORS		SURVIVORS WITH DORSAL SPINE INJURIES TO:					
			DANGEROUS DEGREE		NON-DANGEROUS DEGREE		MINOR DEGREE	
	No.	%	No.	%	No.	%	No.	%
CV-240 Buffalo, N. Y.	22	100.0	0	0.0	0	0.0	0	0.0
CV-240 Springfield, Mo. *	22	66.7	4	23.5	0	0.0	0	0.0
DC-6 Elizabeth, N. J.	33	55.0	1	3.0	1	3.0	0	0.0
C-46 Louisville, Ky.	16	41.0	0	0.0	0	0.0	0	0.0
DC-6A (C-118) McGuire AFB, N. J. (Rearward-facing seats)	21	37.5	1	4.8	0	0.0	0	0.0

\* Five (5) survivors without authoritative medical details not included in the injury columns. Percentage taken from seventeen (17) survivors.

TABLE 8.

## LUMBAR SPINE INJURIES

The high magnitude of vertical force imposed in the Springfield accident is also considered to be the responsible factor for the incidence of dangerous lumbar spine injuries.

NUMBER OF SURVIVORS AND DEGREE OF  
LUMBAR SPINE INJURIES

AIRCRAFT MODEL AND ACCIDENT LOCATION	NUMBER AND PERCENTAGE OF SURVIVORS		SURVIVORS WITH LUMBAR SPINE INJURIES TO:					
			DANGEROUS DEGREE		NON-DANGEROUS DEGREE		MINOR DEGREE	
	No.	%	No.	%	No.	%	No.	%
CV-240 Buffalo, N. Y.	22	100.0	0	0.0	0	0.0	0	0.0
CV-240 Springfield, Mo. *	22	66.7	2	11.8	1	5.9	0	0.0
DC-6 Elizabeth, N. J.	33	55.0	0	0.0	1	3.0	0	0.0
C-46 Louisville, Ky.	16	41.0	0	0.0	0	0.0	0	0.0
DC-6A (C-118) McGuire AFB, N. J. (Rearward-facing seats)	21	37.5	0	0.0	1	4.8	1	4.8

\* Five (5) survivors without authoritative medical details not included in the injury columns. Percentage taken from seventeen (17) survivors.

TABLE 9.

## INTRATHORACIC INJURIES

Injuries of a dangerous degree to the intrathoracic area were reported to have occurred only in the McGuire and Elizabeth accidents; both of these accidents were of similar nature, but involved different directions of seating.

No cases of intrathoracic injuries to a non-dangerous degree were reported in the five accidents. This is an unexpected and informative finding, since accidents involving such severe force and damage conditions as occurred in these crashes would normally be expected to result in a high rate of both dangerous and non-dangerous injury to the thoracic contents - due to the relative body area involved.

NUMBER OF SURVIVORS AND DEGREE OF  
INTRATHORACIC INJURIES

AIRCRAFT MODEL AND ACCIDENT LOCATION	NUMBER AND PERCENTAGE OF SURVIVORS		SURVIVORS WITH INTRATHORACIC INJURIES TO:					
			DANGEROUS DEGREE		NON-DANGEROUS DEGREE		MINOR DEGREE	
	No.	%	No.	%	No.	%	No.	%
CV-240 Buffalo, N. Y.	22	100.0	0	0.0	0	0.0	0	0.0
CV-240 Springfield, Mo.*	22	66.7	0	0.0	0	0.0	0	0.0
DC-6 Elizabeth, N. J.	33	55.0	1	3.0	0	0.0	0	0.0
C-46 Louisville, Ky.	16	41.0	0	0.0	0	0.0	0	0.0
DC-6A (C-118) McGuire AFB, N. J. (Rearward-facing seats)	21	37.5	1	4.8	0	0.0	0	0.0

\* Five (5) survivors without authoritative medical details not included in the injury columns. Percentage taken from seventeen (17) survivors.

TABLE 10.

## UPPER TORSO FRACTURES

No dangerous upper torso fractures (excluding the spine) were sustained by the survivors in the five accidents. Since dangerous upper torso fractures normally are associated with crushing of the thoracic cage, it appears that when such crushing occurs, fatal termination may be expected.

The occurrence of non-dangerous upper torso fractures was almost uniform in the four severe accidents.

NUMBER OF SURVIVORS AND DEGREE OF  
UPPER TORSO FRACTURES

AIRCRAFT MODEL AND ACCIDENT LOCATION	NUMBER AND PERCENTAGE OF SURVIVORS		SURVIVORS WITH UPPER TORSO FRACTURES TO:					
			DANGEROUS DEGREE		NON-DANGEROUS DEGREE		MINOR DEGREE	
	No.	%	No.	%	No.	%	No.	%
CV-240 Buffalo, N. Y.	22	100.0	0	0.0	0	0.0	0	0.0
CV-240 Springfield, Mo. *	22	66.7	0	0.0	4	23.5	0	0.0
DC-6 Elizabeth, N. J.	33	55.0	0	0.0	9	27.3	0	0.0
C-46 Louisville, Ky.	16	41.0	0	0.0	3	18.7	0	0.0
DC-6A (C-118) McGuire AFB, N. J. (Rearward-facing seats)	21	37.5	0	0.0	4	19.0	0	0.0

\* Five (5) survivors without authoritative medical details not included in the injury columns. Percentage taken from seventeen (17) survivors.

TABLE 11.

## UPPER TORSO SURFACE INJURIES

The rates for upper torso surface injuries are not unreasonably divergent - with the exception of the Louisville accident - and indicate that this portion of the body sustains a relatively low rate of injury in this category.

NUMBER OF SURVIVORS AND DEGREE OF  
UPPER TORSO SURFACE INJURIES

AIRCRAFT MODEL AND ACCIDENT LOCATION	NUMBER AND PERCENTAGE OF SURVIVORS		SURVIVORS WITH UPPER TORSO SURFACE INJURIES TO:					
			DANGEROUS DEGREE		NON-DANGEROUS DEGREE		MINOR DEGREE	
	No.	%	No.	%	No.	%	No.	%
CV-240 Buffalo, N. Y.	22	100.0	0	0.0	1	4.5	3	13.6
CV-240 Springfield, Mo. *	22	66.7	0*	0.0	1	5.9	3	17.6
DC-6 Elizabeth, N. J. **	33	55.0	0	0.0	3	9.1	1	3.0
C-46 Louisville, Ky.	16	41.0	0	0.0	0	0.0	2	12.5
DC-6A (C-118) McGuire AFB, N. J. (Rearward-facing seats)	21	37.5	0	0.0	1	4.8	3	14.3

\* Five (5) survivors without authoritative medical details not included in the injury columns. Percentage taken from seventeen (17) survivors.

\*\* 45.5% of the survivors had multiple body bruises.

TABLE 12.

## LOWER TORSO (INTRA-ABDOMINAL) INJURIES

There was a surprising lack of intra-abdominal injury in the accidents with the exception of the Springfield crash.

Considering the severity of the Louisville and Elizabeth crashes - in comparison with the lesser structural demolition sustained in the Springfield accident - it is of interest that none of the survivors in these two accidents was reported to have had dangerous or non-dangerous intra-abdominal injuries.

In the Springfield accident the aircraft was preparing to land after a sustained period of night flying and many of the passengers were reported to have been sleeping or dozing in a reclined position with the safety belts loosely adjusted. It is possible, therefore, that due to the high degree of vertical force imposed during the impact, a few passengers may have partially "submarined" under their belts before they jack-knifed forward. If this occurred, the safety-belt loads could have been imposed on the intra-abdominal tissues rather than against the pelvic bone structure as is normally the case.

NUMBER OF SURVIVORS AND DEGREE OF  
LOWER TORSO (INTRA-ABDOMINAL) INJURIES

AIRCRAFT MODEL AND ACCIDENT LOCATION	NUMBER AND PERCENTAGE OF SURVIVORS		SURVIVORS WITH LOWER TORSO (INTRA-ABDOMINAL) INJURIES TO:					
			DANGEROUS DEGREE		NON-DANGEROUS DEGREE		MINOR DEGREE	
	No.	%	No.	%	No.	%	No.	%
CV-240 Buffalo, N. Y.	22	100.0	1	4.5	0	0.0	0	0.0
CV-240 Springfield, Mo. *	22	66.7	2	11.8	0	0.0	0	0.0
DC-6 Elizabeth, N. J.	33	55.0	0	0.0	0	0.0	0	0.0
C-46 Louisville, Ky.	16	41.0	0	0.0	0	0.0	0	0.0
DC-6A (C-118) McGuire AFB, N. J. (Rearward-facing seats)	21	37.5	1	4.8	1	4.8	0	0.0

\* Five (5) survivors without authoritative medical details not included in the injury columns. Percentage taken from seventeen (17) survivors.

TABLE 13.



## LOWER TORSO (PELVIC) FRACTURES

The wide variation in the occurrence of pelvic fractures is perplexing. In the Springfield and Louisville accidents – in which forward-facing seats tore free – it is difficult to attempt any diagnosis of the reasons for the high rate in one and the low rate in the other.

Lack of severe vertical force in the Elizabeth and Louisville accidents may have been a factor in preventing a higher rate of pelvic fractures in these two accidents, but there is no evidence to support such an assumption.

Likewise, although there is no supporting evidence, it is possible that the rearward-seating configuration in the C-118 McGuire crash may have been associated in some manner with the highest rate recorded in the four severe accidents. However, such a possibility should be viewed with caution.

NUMBER OF SURVIVORS AND DEGREE OF  
LOWER TORSO (PELVIC) FRACTURES

AIRCRAFT MODEL AND ACCIDENT LOCATION	NUMBER AND PERCENTAGE OF SURVIVORS		SURVIVORS WITH LOWER TORSO (PELVIC) FRACTURES TO:					
			DANGEROUS DEGREE		NON-DANGEROUS DEGREE		MINOR DEGREE	
	No.	%	No.	%	No.	%	No.	%
CV-240 Buffalo, N. Y.	22	100.0	0	0.0	0	0.0	0	0.0
CV-240 Springfield, Mo. *	22	66.7	0	0.0	3	17.6	0	0.0
DC-6 Elizabeth, N. J.	33	55.0	0	0.0	1	3.0	0	0.0
C-46 Louisville, Ky.	16	41.0	0	0.0	1	6.3	0	0.0
DC-6A (C-118) McGuire AFB, N. J. (Rearward-facing seats)	21	37.5	0	0.0	5	23.8	0	0.0

\* Five (5) survivors without authoritative medical details not included in the injury columns. Percentage taken from seventeen (17) survivors.

TABLE 14.

## LOWER TORSO SURFACE INJURIES

There were a few cases of non-dangerous surface injuries to the lower torso. As expected, higher rates were sustained in the "minor" category. The Buffalo accident had the highest reported rate. However, this crash involved a very low rate of injuries on an over-all basis, and it appears that the physicians reporting the injuries were meticulous in listing each and every minor injury; a large proportion of the reported minor injuries in the Buffalo accident were bruises of the hips caused by the safety belts. A number of other bruises were apparently caused by the arm-rests.

NUMBER OF SURVIVORS AND DEGREE OF  
LOWER TORSO SURFACE INJURIES

AIRCRAFT MODEL AND ACCIDENT LOCATION	NUMBER AND PERCENTAGE OF SURVIVORS		SURVIVORS WITH LOWER TORSO SURFACE INJURIES TO:					
			DANGEROUS DEGREE		NON-DANGEROUS DEGREE		MINOR DEGREE	
	No.	%	No.	%	No.	%	No.	%
CV-240 Buffalo, N. Y.	22	100.0	0	0.0	1	4.5	12	54.6
CV-240 Springfield, Mo. *	22	66.7	0	0.0	0	0.0	4	23.5
DC-6 Elizabeth, N. J. **	33	55.0	0	0.0	0	0.0	1	3.0
C-46 Louisville, Ky.	16	41.0	0	0.0	0	0.0	3	18.8
DC-6A (C-118) McGuire AFB, N. J. (Rearward-facing seats)	21	37.5	0	0.0	1	4.8	3	14.3

\* Five (5) survivors without authoritative medical details not included in the injury columns. Percentage taken from seventeen (17) survivors.

\*\* 45.5% of the survivors had multiple body bruises.

TABLE 15.

## UPPER EXTREMITY FRACTURES

The accident having the highest rate of fractures to the upper extremities was the Louisville crash which involved non-delethalized forward-facing seats; in fact, this was the only accident in which a dangerous degree of upper extremity fracture was sustained. However, any attempt to relate such a dangerous type of arm injury with the seat design should be done with caution, since this type of injury would normally be expected as a result of a crushing blow.

NUMBER OF SURVIVORS AND DEGREE OF  
UPPER EXTREMITY FRACTURES

AIRCRAFT MODEL AND ACCIDENT LOCATION	NUMBER AND PERCENTAGE OF SURVIVORS		SURVIVORS WITH UPPER EXTREMITY FRACTURES TO:					
			DANGEROUS DEGREE		NON-DANGEROUS DEGREE		MINOR DEGREE	
	No.	%	No.	%	No.	%	No.	%
CV-240 Buffalo, N. Y.	22	100.0	0	0.0	0	0.0	0	0.0
CV-240 Springfield, Mo. *	22	66.7	0	0.0	3	17.6	0	0.0
DC-6 Elizabeth, N. J.	33	55.0	0	0.0	2	6.1	0	0.0
C-46 Louisville, Ky.	16	41.0	1	6.3	8	50.0	0	0.0
DC-6A (C-118) McGuire AFB, N. J. (Rearward-facing seats)	21	37.5	0	0.0	2	9.5	0	0.0

\* Five (5) survivors without authoritative medical details not included in the injury columns. Percentage taken from seventeen (17) survivors.

TABLE 16.

## UPPER EXTREMITY DISLOCATIONS

Surprisingly, there were only two accidents involving this type of injury and these occurred in two widely divergent crashes (Buffalo and Louisville) in relation to accident severity. No reason has been found for the occurrence of this type of injury in accidents varying so much in crash intensity.

NUMBER OF SURVIVORS AND DEGREE OF  
UPPER EXTREMITY DISLOCATIONS

AIRCRAFT MODEL AND ACCIDENT LOCATION	NUMBER AND PERCENTAGE OF SURVIVORS		SURVIVORS WITH UPPER EXTREMITY DISLOCATIONS TO:					
			DANGEROUS DEGREE		NON-DANGEROUS DEGREE		MINOR DEGREE	
	No.	%	No.	%	No.	%	No.	%
CV-240 Buffalo, N. Y.	22	100.0	0	0.0	2	9.1	0	0.0
CV-240 Springfield, Mo. *	22	66.7	0	0.0	0	0.0	0	0.0
DC-6 Elizabeth, N. J.	33	55.0	0	0.0	0	0.0	0	0.0
C-46 Louisville, Ky.	16	41.0	0	0.0	2	12.5	0	0.0
DC-6A (C-118) McGuire AFB, N. J. (Rearward-facing seats)	21	37.5	0	0.0	0	0.0	0	0.0

\* Five (5) survivors without authoritative medical details not included in the injury columns. Percentage taken from seventeen (17) survivors.

TABLE 17.

## UPPER EXTREMITY SURFACE INJURIES

The varying rates shown for minor surface injuries to the upper extremities should be viewed with caution since the reporting of such minor injuries may be less than optimum in those cases where survivors have more severe injuries to various parts of the body. In the Elizabeth accident, 45.5% of the survivors were listed as having sustained multiple body bruises; this description, of course, made it impossible to assign such injuries to any particular body sites.

NUMBER OF SURVIVORS AND DEGREE OF  
UPPER EXTREMITY SURFACE INJURIES

AIRCRAFT MODEL AND ACCIDENT LOCATION	NUMBER AND PERCENTAGE OF SURVIVORS		SURVIVORS WITH UPPER EXTREMITY SURFACE INJURIES TO:					
			DANGEROUS DEGREE		NON-DANGEROUS DEGREE		MINOR DEGREE	
	No.	%	No.	%	No.	%	No.	%
CV-240 Buffalo, N. Y.	22	100.0	0	0.0	1	4.5	2	9.1
CV-240 Springfield, Mo.*	22	66.7	0	0.0	0	0.0	5	29.4
DC-6 Elizabeth, N. J. **	33	55.0	0	0.0	0	0.0	6	18.2
C-46 Louisville, Ky.	16	41.0	0	0.0	1	6.3	5	31.3
DC-6A (C-118) McGuire AFB, N. J. (Rearward-facing seats)	21	37.5	0	0.0	1	4.8	9	42.9

\* Five (5) survivors without authoritative medical details not included in the injury columns. Percentage taken from seventeen (17) survivors.

\*\* 45% of the survivors had multiple body bruises.

TABLE 18.

## LOWER EXTREMITY FRACTURES

In the Louisville accident three of the survivors sustained crushing and/or multiple fractures of the lower extremities of a dangerous degree - this type of injury is normally related to involvement with, and between, heavy structures which impose crushing blows.

However, a number of fractures of the lower extremities were related to contact with the rigid, small-diameter cross tubes in the base frames of the seats; the lower extremities were apparently pinned underneath these frames and then fractured when the occupants "levered" upward and forward with their heels pinned against the floor.

It is of interest that the rates of non-dangerous fractures to the lower extremities were somewhat similar in three of the four severe crashes; the reason for the lower rate in the Elizabeth crash is not apparent except that in this accident some of the survivors occupied seats which did not tear free.

NUMBER OF SURVIVORS AND DEGREE OF  
LOWER EXTREMITY FRACTURES

AIRCRAFT MODEL AND ACCIDENT LOCATION	NUMBER AND PERCENTAGE OF SURVIVORS		SURVIVORS WITH LOWER EXTREMITY FRACTURES TO:					
			DANGEROUS DEGREE		NON-DANGEROUS DEGREE		MINOR DEGREE	
	No.	%	No.	%	No.	%	No.	%
CV-240 Buffalo, N. Y.	22	100.0	0	0.0	0	0.0	0	0.0
CV-240 Springfield, Mo. *	22	66.7	0	0.0	11	64.7	0	0.0
DC-6 Elizabeth, N. J.	33	55.0	0	0.0	6	18.2	1	3.0
C-46 Louisville, Ky.	16	41.0	3	18.8	10	62.5	0	0.0
DC-6A (C-118) McGuire AFB, N. J. (Rearward-facing seats)	21	37.5	0	0.0	10	47.6	0	0.0

\* Five (5) survivors without authoritative medical details not included in the injury columns. Percentage taken from seventeen (17) survivors.

TABLE 19.

## LOWER EXTREMITY DISLOCATIONS

A rather high rate of dislocation of the lower extremities was experienced in the Springfield and Louisville accidents – both of which involved forward-facing seats which tore free. It is of interest that the rate for the McGuire accident – involving rearward-facing seats that tore free – was much lower.

It appears that extensive failure of seats in intact areas of the aircraft is a factor related to such leg injuries.

NUMBER OF SURVIVORS AND DEGREE OF  
LOWER EXTREMITY DISLOCATIONS

AIRCRAFT MODEL AND ACCIDENT LOCATION	NUMBER AND PERCENTAGE OF SURVIVORS		SURVIVORS WITH LOWER EXTREMITY DISLOCATIONS TO:					
			DANGEROUS DEGREE		NON-DANGEROUS DEGREE		MINOR DEGREE	
	No.	%	No.	%	No.	%	No.	%
CV-240 Buffalo, N. Y.	22	100.0	0	0.0	0	0.0	0	0.0
CV-240 Springfield, Mo. *	22	66.7	0	0.0	5	29.4	0	0.0
DC-6 Elizabeth, N. J.	33	55.0	0	0.0	0	0.0	0	0.0
C-46 Louisville, Ky.	16	41.0	0	0.0	6	37.5	0	0.0
DC-6A (C-118) McGuire AFB, N. J. (Rearward-facing seats)	21	37.5	0	0.0	2	9.5	0	0.0

\* Five (5) survivors without authoritative medical details not included in the injury columns. Percentage taken from seventeen (17) survivors.

TABLE 20.

## LOWER EXTREMITY SURFACE INJURIES

Non-dangerous surface injuries to the lower extremities were fairly uniform in rate in the four severe accidents; rates for the minor degree of surface injuries varied extensively.

NUMBER OF SURVIVORS AND DEGREE OF  
LOWER EXTREMITY SURFACE INJURIES

AIRCRAFT MODEL AND ACCIDENT LOCATION	NUMBER AND PERCENTAGE OF SURVIVORS		SURVIVORS WITH LOWER EXTREMITY SURFACE INJURIES TO:					
			DANGEROUS DEGREE		NON-DANGEROUS DEGREE		MINOR DEGREE	
	No.	%	No.	%	No.	%	No.	%
CV-240 Buffalo, N. Y.	22	100.0	0	0.0	0	0.0	7	31.8
CV-240 Springfield, Mo. *	22	66.7	0	0.0	2	11.8	5	29.4
DC-6 Elizabeth, N. J. **	33	55.0	0	0.0	3	9.1	10	30.3
C-46 Louisville, Ky.	16	41.0	0	0.0	2	12.5	13	81.3
DC-6A (C-118) McGuire AFB, N. J. (Rearward-facing seats)	21	37.5	0	0.0	3	14.3	12	57.1

\* Five (5) survivors without authoritative medical details not included in the injury columns. Percentage taken from seventeen (17) survivors.

\*\* 45.5% of the survivors had multiple body bruises.

TABLE 21.



## SUMMARY OF INJURIES

The important types of injuries - excluding surface wounds and dislocations - sustained by the survivors of the four severe transport accidents are shown in Figure 6. The percentages shown include the totals for the injury rates of minor, non-dangerous, and dangerous.

The low rates for intrathoracic and intra-abdominal injuries as compared to the high rates for concussion and lower extremity fracture are vividly evident.

Of interest is the fact that the total for the three areas of the spine (19.5%) is not too dissimilar from the rates for thoracic cage fracture (23.7%) and upper extremity fracture (18.4%) - all three sites of injury being located in the same general body "area".

GROSS SITE AND FREQUENCY OF INJURY SUSTAINED BY  
87 SURVIVORS OF FOUR SEVERE, BUT SURVIVABLE,  
TRANSPORT ACCIDENTS

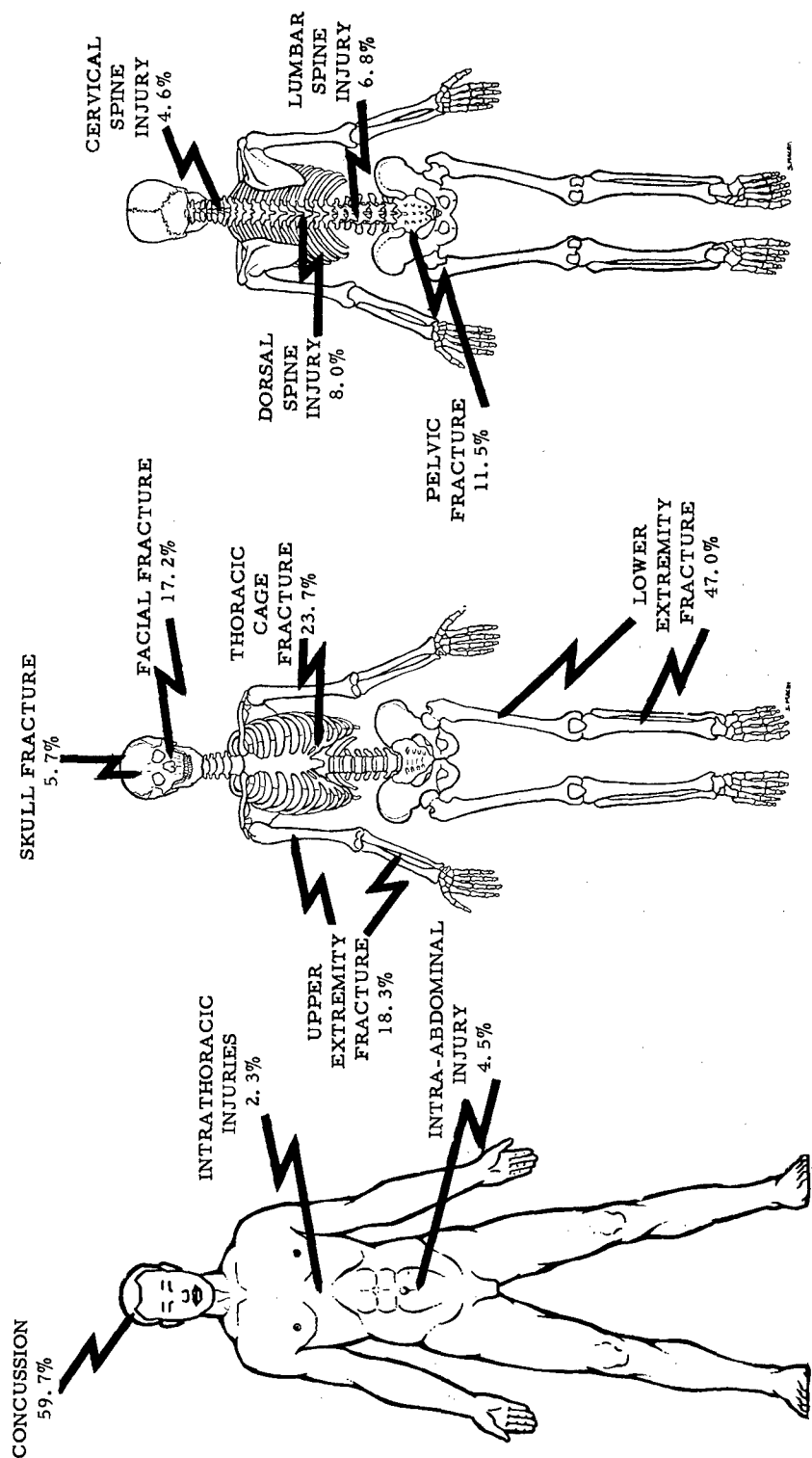


Figure 6.

## APPENDIX A

### LIST OF TYPICAL INJURIES

The gross body areas used in this report for assignment of injury location are:

Head  
Spine  
Upper Torso  
Lower Torso  
Upper and Lower Extremities

The following is a list of typical injuries (and their seriousness) sustained by some of the survivors of the five accidents described in this report:

#### HEAD - Surface Injuries

Minor : Minor lacerations, contusions and abrasions.

Non-dangerous: Moderate lacerations, contusions and abrasions.

#### HEAD - Skeletal Injuries

Minor : Simple fractures of the nose

Non-dangerous: Dislocation, simple and compound fractures of the facial bones.

Dangerous : Skull fractures combined with concussion as evidenced by loss of consciousness of more than five minutes.

#### HEAD - Intracranial (Concussion)

Minor : Concussion with no loss of consciousness or dazed.

Non-dangerous: Concussion with loss of consciousness from five to thirty minutes without evidence of other intracranial injury.

Dangerous : Concussion with loss of consciousness exceeding thirty minutes.

Contusion of brain.

## SPINAL

Minor : Lumbar strain.

Non-dangerous: Fractures of the spinous processes.

Simple fractures of the vertebral bodies of the dorsal and lumbar spine with no cord involvement.

Cervical strain.

Dangerous : Simple fractures of the vertebral bodies of the cervical spine.

Compression fractures of the vertebral bodies of the dorsal spine and lumbar 1 and 2.

## UPPER TORSO - Surface Injuries

Minor : Minor contusions, lacerations and abrasions.

Non-dangerous: Moderate contusions, lacerations and abrasions.

## UPPER TORSO - Skeletal Injuries

Non-dangerous: Fractures of the ribs, sternum, clavicle and scapula.

Acromio-clavicular and sterno-clavicular separation, dislocation of sterno-clavicular joint.

## UPPER TORSO - Internal Injuries (Intrathoracic)

Dangerous : Hemothorax.

Intra-pulmonary hemorrhage.

## LOWER TORSO - Surface Injuries

Minor : Minor contusions, lacerations and abrasions.

Non-dangerous: Moderate contusions, lacerations and abrasions.

### LOWER TORSO - Pelvic Fractures

Non-dangerous: Simple fractures, dislocations and separations.

### LOWER TORSO - Internal Injuries (Intra-abdominal)

Dangerous : Tear of spleen with hemorrhage.  
: Intra-abdominal hemorrhage.  
: Injury to genito-urinary tract.  
: Contusion of kidney.

### UPPER AND LOWER EXTREMITY - Surface Injuries

Minor : Minor contusions, lacerations and abrasions.

Non-dangerous: Moderate contusions, lacerations and abrasions.

Avulsion of deltoid muscle.

Deep laceration of posterior surface of leg with protrusion of muscle.

Punched-out wounds.

### UPPER AND LOWER EXTREMITY - Skeletal Fractures and Dislocations

Non-dangerous: Simple, complete, incomplete, compound, comminuted, and compound comminuted fractures.

Impacted type fractures.

Dislocations and separations with and without fracture.

Severance of Achilles tendon.

Dangerous : Multiple fractures.

Crushed and mangled extremities.

## APPENDIX B

### TYPICAL Av-CIR MEDICAL REPORT

The following five pages are a reproduction of a typical Av-CIR medical report describing the injuries sustained by a survivor involved in one of the accounts reviewed in this report.

The design and format of this Av-CIR medical form has proven of value in eliciting pertinent medical information with a minimum of time required for its completion by the physician. In addition, the use of large figures - and in particular, the enlarged head and spinal column - has aided materially in the recording of exact sites and dimensions of injuries.

It will be noted that the report also requests the attachment of copies of the clinical records and/or autopsy reports, where these are available.

All medical data used by Av-CIR in its research is derived from the authoritative information contained in reports such as these.

AVIATION CRASH INJURY RESEARCH  
OF  
CORNELL UNIVERSITY

5-15-1

(Associated with Cornell University Medical College)

This Medical Form is to be completed by medical personnel having charge of a person injured or killed in an aircraft accident, and mailed to: Aviation Crash Injury Research, ~~2713 East Airline Way, Sky Harbor Airport, Phoenix, Arizona.~~

THE ASSISTANCE OF THE MEDICAL PROFESSION IN PROVIDING THE FOLLOWING MEDICAL DATA IS URGENTLY NEEDED IN DEVELOPING CRASH PROTECTION FOR PERSONS INVOLVED IN FUTURE AIRCRAFT ACCIDENTS.

THE RESEARCH WORK LEADING TO THIS DEVELOPMENT OF CRASH PROTECTION IS BEING CONDUCTED BY THE AVIATION CRASH INJURY RESEARCH PROJECT OF CORNELL UNIVERSITY: THE PROJECT IS A MEMBER OF THE CORNELL COMMITTEE FOR TRANSPORTATION SAFETY RESEARCH AND ACTS IN COOPERATION WITH THE UNITED STATES AIR FORCE, NAVY, OFFICE OF NAVAL RESEARCH, CIVIL AERONAUTICS ADMINISTRATION AND THE CIVIL AERONAUTICS BOARD.

THE MEDICAL DATA SUPPLIED ON THIS FORM WILL BE ANALYZED AND CORRELATED WITH PERTINENT ACCIDENT DETAILS BY AV-CIR ANALYSTS; THE RESULTING STATISTICAL AND QUALITATIVE EVIDENCE . ON CAUSES OF EXCESSIVE EXPOSURE TO INJURY IN SURVIVABLE TYPE ACCIDENTS . WILL BE DIRECTED TO AIRCRAFT DESIGNERS, MILITARY AND CIVILIAN SAFETY ENGINEERS, AND OTHER RESEARCH GROUPS.

INTEGRATION OF THIS DATA INTO THE ENGINEERING DESIGN OF AIRCRAFT STRUCTURES . AND COMPONENTS SUCH AS SEATS, SAFETY BELTS, INSTRUMENT PANELS, ETC. WILL PERMIT REALISTIC IMPROVEMENTS IN CRASH SURVIVAL DESIGN, THEREBY PREVENTING OR MODIFYING INJURIES IN FUTURE SURVIVABLE AIRCRAFT ACCIDENTS.

ACCIDENT LOCATION ~~Over the New Jersey~~ (CITY OR TOWN) ~~Delaware~~ (STATE) DATE OF ACCIDENT ~~July 1, 1951~~

PATIENT TREATED BY: PHYSICIAN ☒ EXAMINED BY CORONER ☐ OTHER ☐

HOSPITALIZED ☒ FIRST AID ☐ DATE OF TREATMENT ~~July 1, 1951~~ NO TREATMENT ☐

NAME OF HOSPITAL ~~St. Mary's Hospital, New York~~ ADDRESS ~~100 West 125th Street, New York~~ (NO.) (STREET) (CITY OR TOWN) (STATE)

THIS REPORT IS BASED ON OBSERVATIONS MADE DURING WHAT PERIOD AFTER ACCIDENT? \_\_\_\_\_

All information furnished by physicians is treated as privileged medical information and will be used for research purposes only. The perforated section below, containing the names of physician and patient, will be torn off and destroyed on completion of analysis.

NAME OF INJURED PERSON (MR.) ~~Robert H. White~~ (MRS.) ~~Robert H. White~~ (MISS) ~~Robert H. White~~ ADDRESS ~~100 West 125th Street, New York~~ (NO.) (STREET) (CITY OR TOWN) (STATE)

NAME OF PERSON TREATING PATIENT ~~Dr. J. H. White~~ ADDRESS ~~100 West 125th Street, New York~~ (NO.) (STREET) (CITY OR TOWN) (STATE)

TITLE ~~Dr. J. H. White~~ DATE OF THIS REPORT ~~July 1, 1951~~ (MO.) (DAY) (YEA)

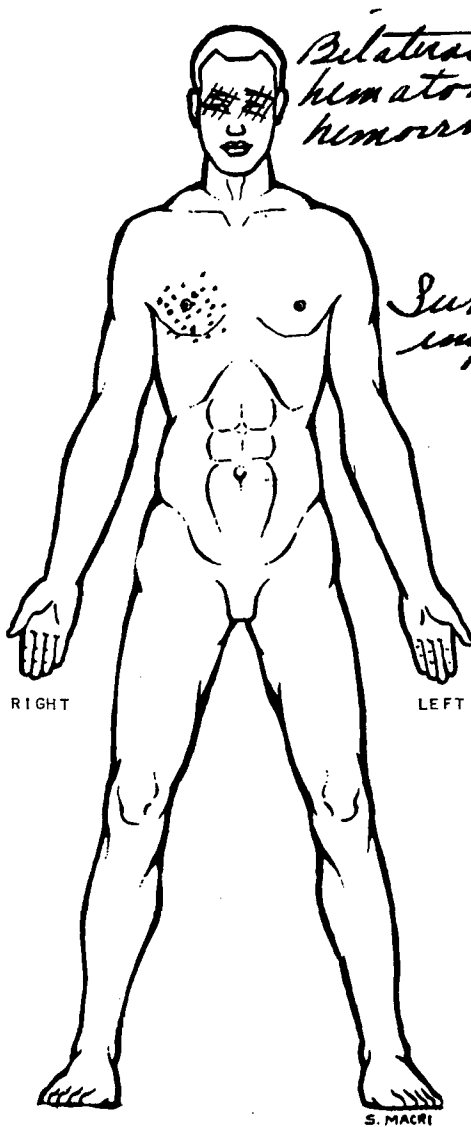
## SURFACE INJURIES ONLY

DESCRIBE - AND SHOW GRAPHICALLY BY OUTLINING AND SHADING AFFECTED AREAS -

ALL LACERATIONS, ABRASIONS, CONTUSIONS, PUNCTURE WOUNDS, SPRAINS AND BURNS. (SEE SAMPLE, PAGE 6.)

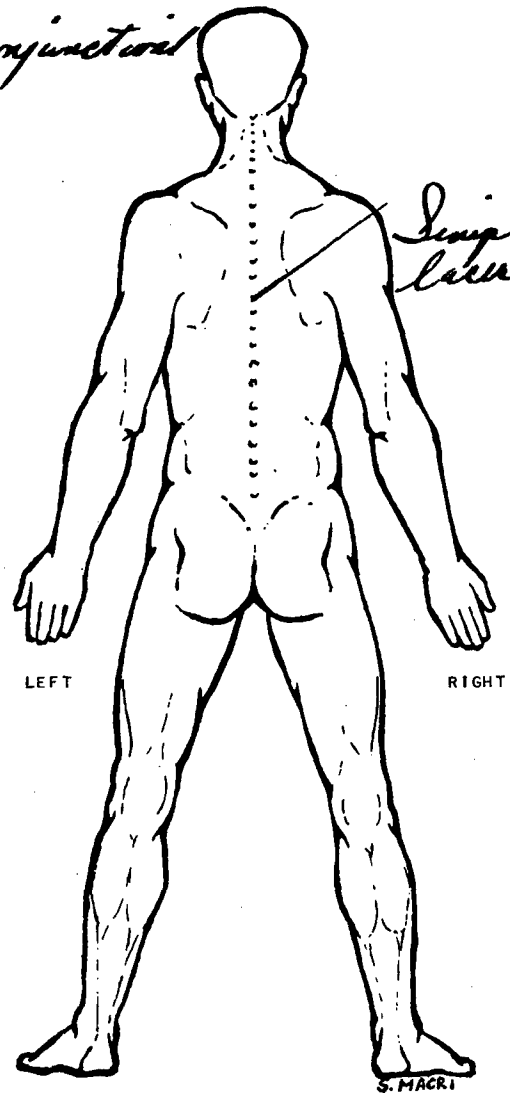
PLEASE RECORD ALL INJURIES NO MATTER HOW TRIVIAL, WHETHER PATIENT LIVED OR DIED.

Trivial injuries, although seemingly unimportant, are usually the result of bodily contact with aircraft structure or objects, and become highly important when related to finding specific causes of injury.



*Bilateral periorbital  
hematomas with subconjunctival  
hemorrhages*

*Subcutaneous  
emphysema*



*Single  
laceration*

PLEASE DO NOT WRITE BELOW THIS LINE

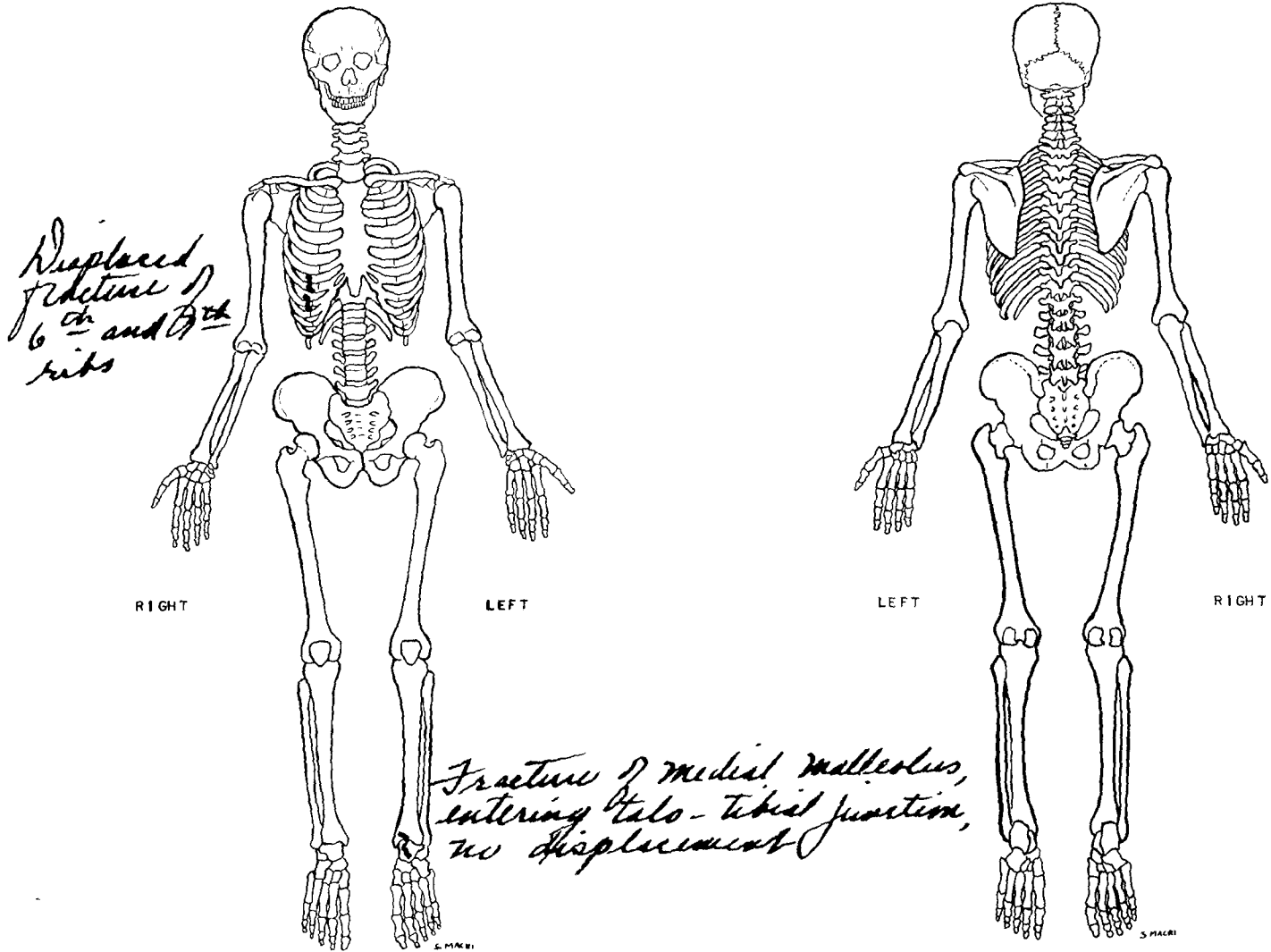


## SKELETAL INJURIES ONLY

DESCRIBE - AND SHOW GRAPHICALLY BY OUTLINING -

ALL FRACTURES BY TYPE (SIMPLE, COMPOUND, COMMUNED, ETC.) AND DISLOCATIONS, INDICATING DIRECTION OF DISPLACEMENT. (SEE SAMPLE, PAGE 6.)

FOR DETAILED INJURIES TO THE SKULL AND SPINE, USE PAGE 4.



## DETAILS OF SKULL FRACTURES AND BRAIN INJURY

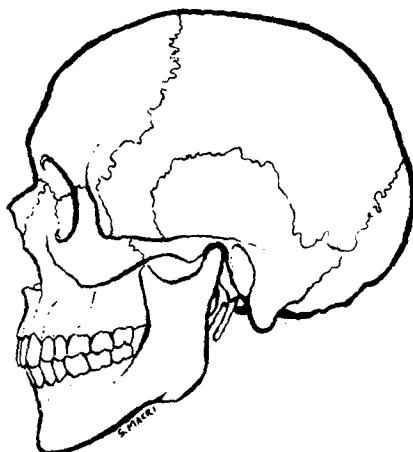
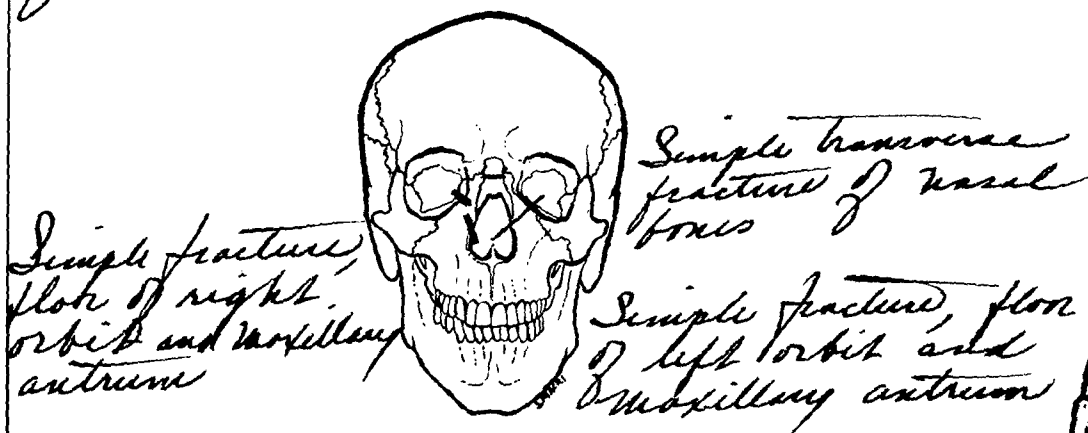
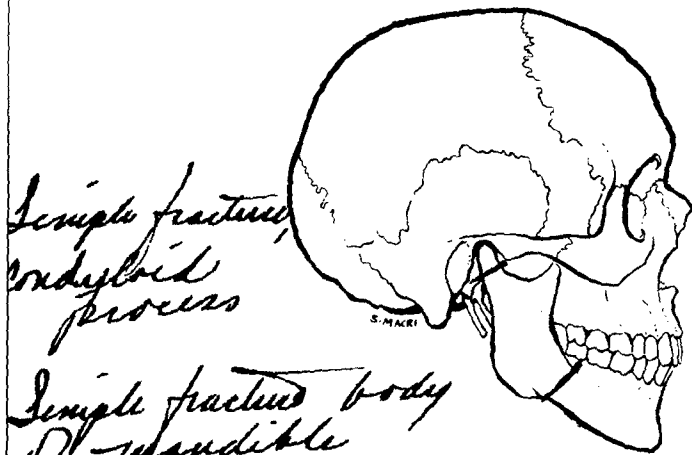
## DESCRIBE AND SHOW GRAPHICALLY:

1. ALL FRACTURES, BY TYPE (SIMPLE, DEPRESSED, OR INDIRECT, ETC.).
2. SITES OF BRAIN LESIONS, IF ANY.
3. DISLOCATIONS OF MANDIBLE.

## DETAILS OF SPINAL INJURIES

## DESCRIBE AND SHOW GRAPHICALLY:

1. ALL FRACTURES OF SPINAL COLUMN (SIMPLE, COMPRESSED, ETC.).
2. DISLOCATION AND DIRECTION OF DISPLACEMENT.
3. SITES OF CORD DAMAGE, IF ANY.



1. PLEASE STATE PATIENT'S: AGE 19 WEIGHT 140 HEIGHT 5'7" SEX M
2. IF INJURIES WERE FATAL, INDICATE DATE                      AND TIME (HOUR)                      OF DEATH.
3. IF INJURIES WERE FATAL - PLEASE ATTACH COPY OF AUTOPSY REPORT. IF REPORT IS NOT AVAILABLE, LIST MOST SIGNIFICANT FINDINGS IN SECTION 5, AND SPECIFY THE INJURIES, IN THEIR ORDER OF IMPORTANCE, WHICH COULD HAVE CAUSED FATALITY.
4. IF INJURIES WERE SURVIVED - EVEN TEMPORARILY. PLEASE ATTACH COPY OF CLINICAL RECORD. IF NOT AVAILABLE GIVE GENERAL DESCRIPTION, IN SECTION 5, OF PATIENT'S CONDITION, MENTAL STATUS, TEMPERATURE, B.P., PULSE, RESPIRATION, AND ANY OTHER MEDICAL INFORMATION OF IMPORTANCE.
5. (SEE SECTIONS 3 AND 4.) BP-134/84 P-76 R-18

*Injuries noted and right pneumothorax. Patient was conscious on admission and oriented.*

6. IF HEAD INJURIES WERE SUSTAINED, STATE PERIOD OF UNCONSCIOUSNESS: (DAYS)            (HOURS) 1 (MIN.)
- WAS CONCUSSION: MILD ☐ MODERATE ☐ SEVERE ☒ CAUSE OF DEATH ☐
7. IF SHOCK WAS PRESENT, WAS IT: MILD ☒ MODERATE ☐ SEVERE ☐ CAUSE OF DEATH ☐
8. LIST AND DESCRIBE ANY INTERNAL INJURIES OR EVIDENCE OF INJURY TO INTERNAL ORGANS.

*None*

9. IF INTERNAL INJURIES WERE SUSTAINED, PLEASE INDICATE PROBABLE CAUSE IN BOXES BELOW:

COMPRESSIVE BLOW WITHOUT FRACTURE OR PENETRATION ☐ INERTIA OF INTERNAL ORGANS ☐ UNKNOWN ☐  
 PENETRATION OF FOREIGN OBJECT ☐ BONE PENETRATION ☐

10. IF BRAIN LESIONS WERE SUSTAINED, PLEASE INDICATE PROBABLE CAUSE IN BOXES BELOW:

PENETRATION OF FOREIGN OBJECT ☐ BONE PENETRATION ☐ UNKNOWN ☐  
 INERTIA OF BRAIN MASS ☐ CONCUSSION ☒

11. PLEASE COMMENT ON ANY NEUROLOGICAL COMPLICATIONS RESULTING FROM HEAD AND/OR SPINAL INJURIES.

*None*

## APPENDIX C

### DEGREES OF INJURY\* USED BY Av-CIR

(Revised 8/58)

**	Degrees ***	
1-	1	<u>Trivial or None</u>
4-	2	<u>Minor</u> "Minor" contusions, lacerations, abrasions in any area(s) of the body. Sprains, fractures, dislocations of fingers, toes, or nose. Dazed or slightly stunned. Mild concussion evidenced by mild headache, with no loss of consciousness.
15-	3	<u>Moderate</u> - but not dangerous. "Moderate" contusions, lacerations, abrasions in any area(s) of the body. Sprains of the shoulders or principal articulations of the extremities. Uncomplicated, simple or green-stick fractures of extremities and jaw. Concussion as evidenced by loss of consciousness not exceeding 5 minutes, without evidence of other intracranial injury.
28-	4	<u>Severe</u> - but not dangerous. Survival normally assured. Extensive lacerations without dangerous hemorrhage. Compound or comminuted fractures, or simple fractures with displacements. Dislocations of the arms, legs, shoulders or pelvisacral processes. Fractures of the facial bones. Severe sprains of the cervical spine. Fracture of transverse and/or spinous processes of the spine, without evidence of spinal cord damage. Simple fractures of vertebral bodies of the dorsal and/or lumbar spine, without evidence of spinal cord damage. Compression fractures of L-3-4-5. Skull fracture without evidence of concussion or other intracranial injury. Concussion as evidenced by loss of consciousness of over 5 and up to 30 minutes, without evidence of other intracranial injury.
45-	5	<u>Serious</u> - dangerous, but survival probable. Lacerations with dangerous hemorrhage. Simple fractures of vertebral bodies of the cervical spine, without evidence of spinal cord damage. Compression fractures

of vertebral bodies of dorsal spine and/or of L-1 and L-2, without evidence of spinal cord damage. Crushing or multiple fractures of the extremities and/or of the chest. Indication of moderate intrathoracic or intra-abdominal injury. Skull fracture with concussion as evidenced by loss of consciousness up to 30 minutes. Concussion as evidenced by loss of consciousness of over 30 minutes to 2 hours, without evidence of other intracranial injury.

- |      |    |   |
|------|----|---|
| 66-  | 6  | <p><u>Critical</u> - dangerous, survival uncertain or doubtful. (Includes fatal terminations beyond 24 hours.) Evidence of dangerous intrathoracic or intra-abdominal injury. Fractures or dislocations of vertebral bodies of cervical spine with evidence of cord damage. Compression fractures of vertebral bodies of dorsal spine, and/or L-1, L-2, with evidence of spinal cord damage. Skull fracture with concussion as evidenced by loss of consciousness beyond 30 minutes. Concussion as evidenced by loss of consciousness beyond 2 hours. Evidence of critical intracranial injury.</p> |
| 91-  | 7  | <p><u>Fatal</u> - within 24 hours of accident. Fatal lesions in single region of the body, with or without other injuries to the 4th degree.</p>  |
| 120- | 8  | <p><u>Fatal</u> - within 24 hours of accident. Fatal lesions in single region of the body, with other injuries to 5th or 6th degree.</p>  |
| 153- | 9  | <p><u>Fatal</u><br/>Fatal lesions in two regions of the body, with or without other injuries elsewhere.</p>   |
| 190- | 10 | <p><u>Fatal</u><br/>Fatal lesions in three or more regions - up to and including demolition of the body.</p>  |

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\* Based on observations during first 48 hours after injury and previously normal life expectancy.

\*\* Weighted value for degrees of total injury.

\*\*\* Degrees of total injury.

<p>Av-CIR-5-SS-96</p> <p>July 1958</p> <p>Aviation Crash Injury Research of Cornell University. GROSS PATTERN OF INJURY OF 109 SURVIVORS OF FIVE TRANSPORT ACCIDENTS. A. Howard Hasbrook July 1958. 54p. photo., tab. (Av-CIR-5-SS-96)</p> <p>The gross pattern of injury - site, frequency, and seriousness - of 109 survivors of five transport accidents is shown. The accidents include four extremely severe conditions of crash force - and aircraft damage; the fifth involved moderate crash force and moderate aircraft damage. Two of the crashes - one of which involved rearward-facing seats - were of similar nature. Lack of delethalized design in the seat structures and lack of effective "tie-down" of seats were factors in producing injury in survivable areas in three of the accidents. The two principal types of injuries sustained by the survivors were concussion (59.5%) and fractures of the lower extremities (47.1%).</p>	<ol style="list-style-type: none"><li>1. Injuries, Survivor</li><li>2. Accidents, Aircraft</li><li>3. Seats, Forward-facing</li><li>4. Seats, Rearward-facing</li><li>5. Seats, Tie-down of</li><li>6. Seats, Delethalization of</li></ol> <ol style="list-style-type: none"><li>I. A. Howard Hasbrook</li><li>II. Av-CIR-5-SS-96</li></ol>
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